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(54) Abstract Title
A resistance welding electrode formed with a recess

(57) A resistance welding electrode 10 for supplying an electric current to metal workpieces to weld the workpieces together comprises a generally cylindrical body 12 of an electrically conductive material having a tip 17 for contacting a workpiece. The tip is formed with a recess 16 which may give the tip a generally annular workpiece contacting surface. The recess may be filled with an electrical and heat resistant material 18, eg a ceramic disc or ceramic cement. Alternatively the recess may be coated with an electrical and heat resistant material such as aluminium oxide (see fig 11).

Fig. 1

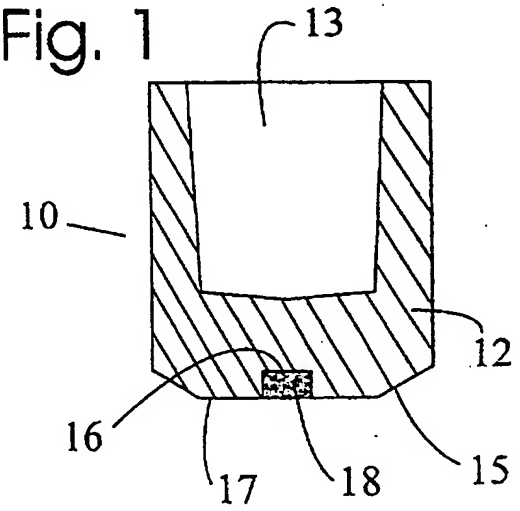

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Fig. 1

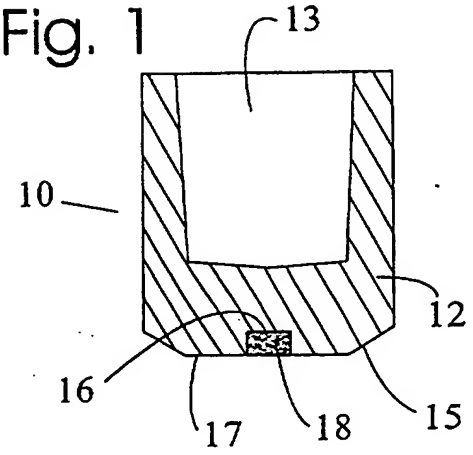


Fig. 2

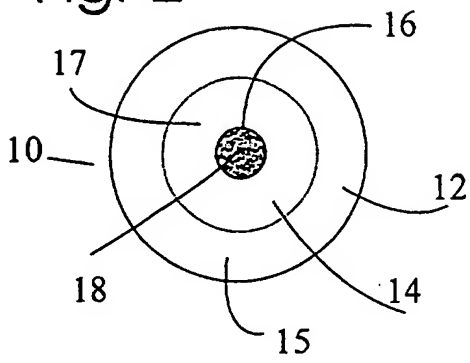


Fig. 3

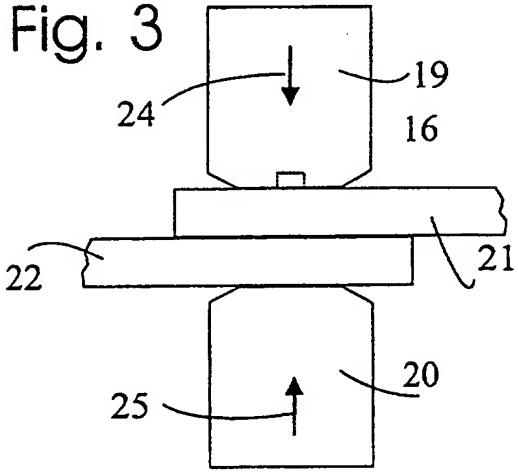


Fig. 4

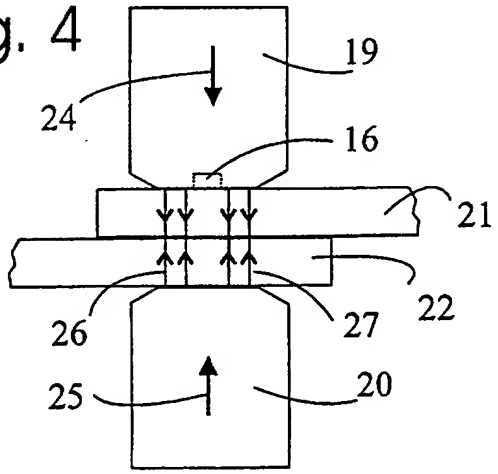


Fig. 5

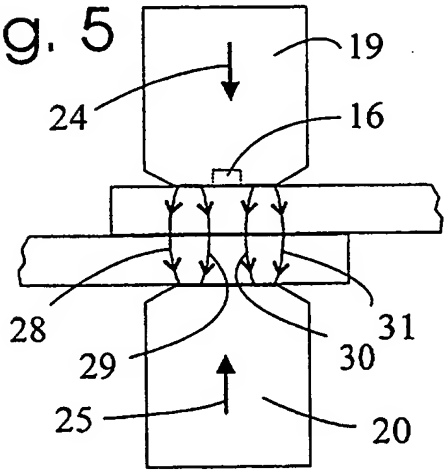


Fig. 6

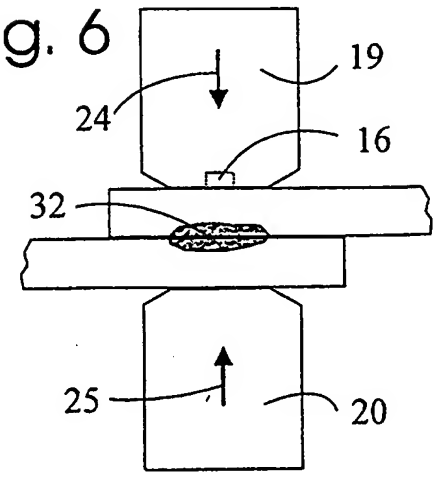


Fig. 8

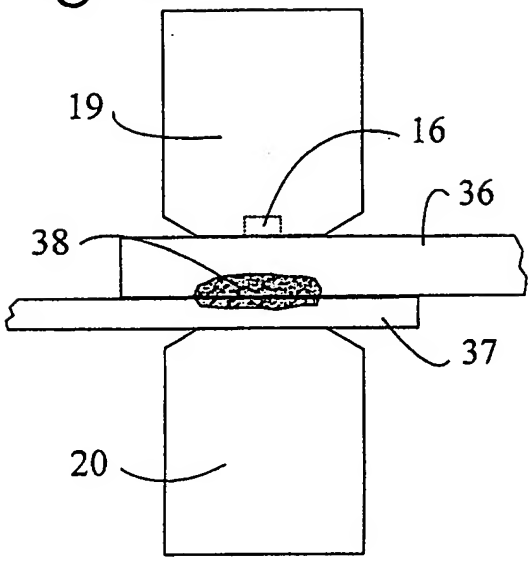


Fig. 7

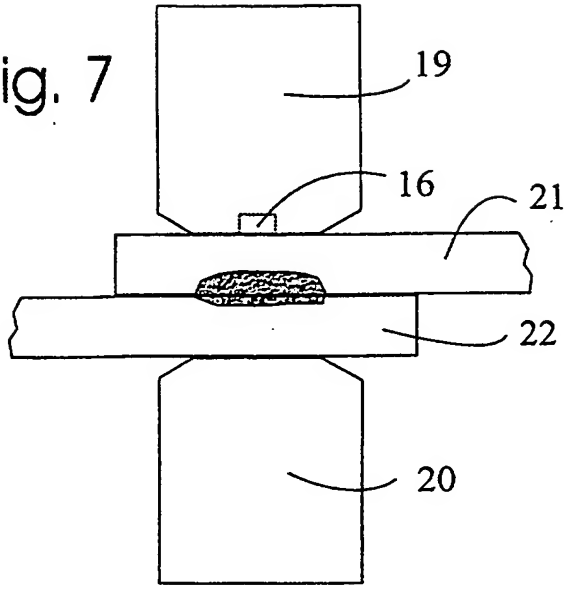


Fig. 9

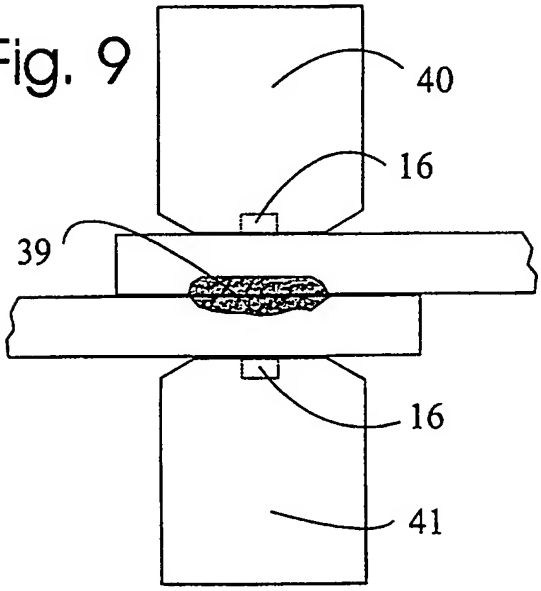


Fig. 10

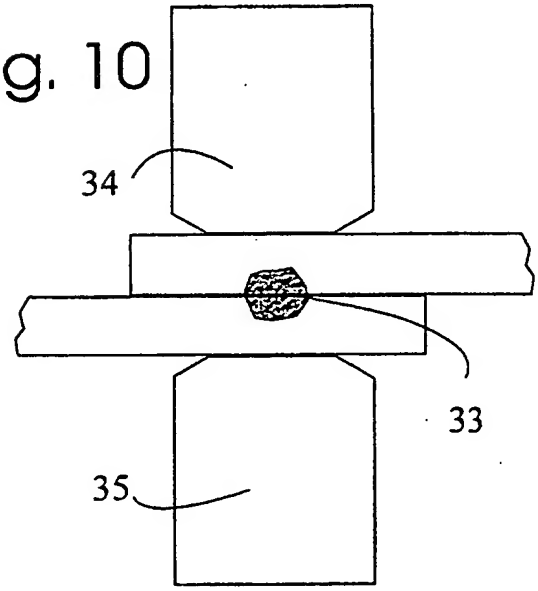
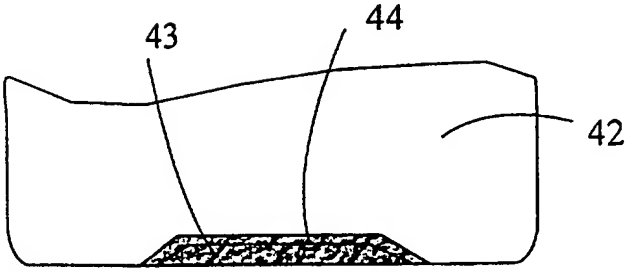


Fig. 11



IMPROVED RESISTANCE WELDING ELECTRODE

Field of the invention

This invention relates to electrodes for resistance welding and also a method of welding using such electrodes.

Background of the invention

Resistance welding is typically use to provide spot welds between overlying sheet metal members. It is a welding process in very widespread use in the automotive field for the manufacture of sheet metal body structures and the manufacture of road wheels.

Copper electrodes are brought into pressure contact with opposite faces of the overlying sheet steel members and an electric current, which may be AC or DC is passed between the electrode through the two metal sheets. Heat is generated by the electric current sufficient to cause localised melting and fusion of the facing area of metal. The fused molten volume of generally disc shape is called the weld nugget. It is desirable that, for a given diameter of electrode the weld nugget should have a high aspect ratio (that is, the width of the weld nugget divided by its height).

Object of the invention

The welding electrode of the present invention provides improved weld nugget aspect ratio.

Summary of the invention

According to the invention, we provide a resistance welding electrode for supplying an electric current to metal workpieces to weld the workpieces to each other comprising a generally cylindrical body of an electrically conductive

material having a tip for contacting a workpiece characterised in that the tip is formed with a recess giving the tip a generally annular workpiece contact surface.

Preferably the tip material is copper and the recess is filled with a material, such as a ceramic, which is both an electrical and thermal insulator.

According to another aspect of the invention, a welding process for welding together two sheet metal workpieces comprising the following steps:

a) clamping the two workpieces between opposing welding electrodes;

b) passing a welding current between the electrodes to cause heating and localised melting of a weld nugget extending between the workpieces in the area of the electrodes;

c) discontinuing the welding current and then releasing the workpieces;

characterised in that at least one of the welding electrodes is formed with a recess giving the tip a generally annular workpiece contact surface, whereby a weld nugget of low aspect ratio is achieved.

Brief description of the drawings

The invention will now be described further, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is an axial section of a resistance welding electrode embodying the invention;

Figure 2 is an end view of the welding electrode of Figure 1;

Figure 3 illustrates the initial application pressure in a first phase of a welding operation using the electrode of the invention;

Figure 4 illustrates the initial application electric current in addition to pressure in a second phase of a welding operation using the electrode of the invention;
Figure 5 illustrates the effect of continuing application of electric current in addition to pressure in a third phase of a welding operation using the electrode of the invention;
Figure 6 illustrates the formation of the weld nugget in final phase of a welding operation using the electrode of the invention;
Figure 7 shows a typical weld formed using an electrode of the invention in combination with a conventional electrode, the weld nugget displaying a high aspect ratio and having greater depth in the sheet contacting the electrode of the invention;
Figure 8 shows a typical weld formed in sheet metal workpieces of dissimilar thickness using an electrode of the invention contacting the thicker sheet in combination with a conventional electrode contacting the thinner sheet, the weld nugget having greater depth in the thicker sheet than the thinner sheet and thereby reducing risk of loss of weld integrity by penetration of the weld nugget through full thickness of the thinner material;
Figure 9 shows a weld formed in sheets of similar thickness using two electrodes embodying the invention, the weld nugget displaying a high aspect ratio and even penetration into both workpieces; and
Figure 10 shows a typical weld formed using conventional electrodes and displaying a lower aspect ratio weld nugget concentrated in an area less that the contact area of the electrodes;
Figure 11 shows an alternative embodiment of the invention.

Detailed description of the drawings

Referring to Figures 1 and 2, a resistance welding electrode 10 comprises a cylindrical body 12 formed with a mounting recess 13 to enable the electrode to be assembled on a weld

probe (not shown) of a resistance welding machine (not shown) for spot welding of sheet metal workpieces.

The electrode has a tip 14 for contacting a workpiece. The tip is formed with a chamfered rim 15. In accordance with the invention, the tip has a disc shaped recess 16 centred on the axis of the electrode and forming an annular contact surface 17. The recess 15 is filled with an insulating material 18. The material 18 may be a ceramic disc cemented into the tip or may be formed by ceramic cement applied to the recess 16 and finished flush with the annular contact surface 17.

A welding process using the recessed electrode of the invention is illustrated in Figures 3 to 6. The upper electrode 19 is as shown in Figure 1, the lower electrode 20 is conventional. The electrodes 19, 20, fixed to the welding probes of a spot welding machine are brought into pressure contact with sheet metal workpieces 21 and 22 in a first phase shown in Figure 3. Pressure is applied in the direction of the arrows 24 and 25.

In the next step shown in Figure 4, a welding current which may be AC or DC is passed between the electrodes. Initially, the current path is straight and concentrated in an annular region and shown by arrows 26, 27 since the current follows the shortest path of least electrical resistance.

The metal through which the current flows is heated by the current and its resistance increases as its temperature rises. The direct path is no longer the path of least resistance and the current paths tend to bow outwards and inwards of the annular ring defined by contact surface 17 as shown by arrows 28, 29, 30 and 31 in Figure 5.

A weld nugget 32 of high aspect ratio is formed as shown in Figure 6. The current is turned off and a short time later

the pressure 24, 25 is released. The shape of weld nugget 32 may be compared with the lower aspect ratio of weld nugget 33 in Figure 10 which depicts a typical weld nugget produced using two conventional electrodes 34 and 35.

Figure 7 shows in more detail the geometry of the weld nugget 32 produced by the process described with reference to Figures 3 to 6. It is of relatively high aspect ratio and is thicker in the upper workpiece 21 contacted by the recessed electrode 19 than in the lower workpiece 22 contacted by the conventional electrode 20.

The effect of differential penetration seen in Figure 7 may be used to advantage when welding sheet metal of dissimilar thicknesses. If the recessed electrode 19 of the invention is used for the thicker workpiece 36 and a conventional electrode 20 is used for the thinner workpiece 37 the result, shown in Figure 7 is a weld nugget 38 having greater depth in the thicker sheet 36 than in the thinner sheet 37, thereby reducing risk of loss of weld integrity by penetration of the weld nugget through the full thickness of the thinner material. This asymmetry of the weld nugget can be attributed to the conservation of heat on the side having the electrode with the ceramic insert.

Figure 9 shows a symmetrical weld nugget 39, achieved using recessed upper and lower electrodes 40 and 41.

The area of the recess 16 as a proportion of the working area of the tip 14 may be between 25 and 35%, preferably about 35% and the depth is of the order of 4 mm.

A further embodiment of the invention is shown in Figure 11. A resistance welding electrode 42 is formed with a shallow central recess 43 of depth about 1mm. Compared to the embodiments described above the recess has a lower aspect

ratio. Recess 43 is left unfilled but it is coated, as shown as 44 with an insulating material such as aluminium oxide.

CLAIMS

1. A resistance welding electrode for supplying an electric current to metal workpieces to weld the workpieces to each other comprising a generally cylindrical body of an electrically conductive material having a tip for contacting a workpiece characterised in that the tip is formed with a recess giving the tip a generally annular workpiece contact surface.

2. A resistance welding electrode as claimed in claim 1 characterised in that the recess is filled with an electrical and heat insulating material.

3. A resistance welding electrode as claimed in claim 1 characterised in that the recess is coated with an electrical and heat insulating material.

4. A resistance welding electrode as claimed in claim 2 or claim 3 characterised in that the electrical and heat insulating material is a ceramic material.

5. A resistance welding electrode substantially as hereinbefore described with reference to and as shown in Figures 1 to 9 or Figure 11 of the accompanying drawings.

6. A welding process for welding together two sheet metal workpieces comprising the following steps:

a) clamping the two workpieces between opposing welding electrodes;

b) passing a welding current between the electrodes to cause heating and localised melting of a weld nugget extending between the workpieces in the area of the electrodes;

c) discontinuing the welding current and then releasing the workpieces;

characterised in that at least one of the welding electrodes is as claimed in any one of the preceding claims, whereby a weld nugget of low aspect ratio is achieved.

7. A welding process as claimed in claim 6 in which both electrodes are as claimed in any one of claims 1 to 5.

8. A welding process as claimed in claim 6 in which only one of the electrodes is as claimed in any one of claims 1 to 4 and in which the workpieces are of dissimilar thickness, the thicker workpiece being contacted by the electrode with recessed tip.

9. A welding process substantially as hereinbefore described with reference to an as shown in Figures 3 to 8 of the accompanying drawings.

Application No: GB 0002295.4 **Examiner:** Gareth Prothero
Claims searched: 1 to 9 **Date of search:** 12 July 2000

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): B3R R2G

Int Cl (Ed.7): B23K 9/26, 11/30, 35/00, 35/02

Other: Online: WPI, EPODOC, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 1151353 A	(ROLLS-ROYCE) see whole document.	1, 6 & 7
X	GB 0532649 A	(BRADLEY & CO.) see whole document.	1 to 4, 6 & 7
X	WO 92/14577 A1	(TUFFALOY) see especially indentation 100 in fig 1.	1, 6 & 7
X	JP 040046684 A	(TOYOTA) 17.02.1992 (see figures, and WPI Abstract Accession No. 1992-102306/13).	1, 6 & 7
X	JP 610020699 A	(MITSUI) 29.01.1986 (see figures, and WPI Abstract Accession No. 1986-071820/11).	1, 6 & 7
X	JP 580074290 A	(TANAKA) 04.05.1983 (see figures, and WPI, Abstract Accession No. 1983-57122K/24).	1, 6 & 7

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Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.